CLAIMS TO INVENTION

1. A hand-supportable Imaging-Based Bar Code Symbol Reader having a multi-mode bar code decode processor which is dynamically reconfigured in response to real-time decode processing operations carried out on captured images.

2. A hand-supportable imaging-based bar code reading system having an integrated LED-based illumination subsystem for generating a visible narrow-area illumination beam for aiming on a target object and illuminating a 1D bar code symbol aligned therewith during a narrow-area image capture mode of the system, and thereafter illuminating randomly-oriented 1D or 2D bar code symbols on the target object during a wide-area image capture mode of the system.

3. A hand-supportable Imaging-Based Bar Code Symbol Reader employing an integrated Multi-Mode Illumination Subsystem which generates a visible narrow-area illumination beam for aiming onto a target object, then illuminates a 1D bar code symbol aligned therewith, captures an image thereof, and thereafter generates a wide-area illumination beam for illuminating 1D or 2D bar code symbols on the object and capturing an image thereof for decode processing.

4. A hand-supportable Imaging-Based Bar Code Symbol Reader employing automatic object presence and range detection to control the generation of near-field and far-field wide-area illumination beams during bar code symbol imaging operations.

5. A hand-supportable Imaging-Based Bar Code Symbol Reader employing a CMOS-type image sensor using global exposure control techniques.

6. A hand-supportable Imaging-Based Bar Code Symbol Reader employing a CMOS-type image sensor with a band-pass optical filter integrated within the hand-supportable housing thereof.

7. A hand-supportable imaging-based auto-discriminating 1D/2D bar code symbol reader employing a multi-mode code symbol reading subsystem dynamically reconfigurable in response to real-time image analysis during bar code reading operations.

8. A hand-supportable Imaging-Based Bar Code Symbol Reader employing a continuously operating automatic illumination and exposure control subsystem.

9. An Imaging-Based Bar Code Symbol Reader employing a multi-mode LED-based illumination subsystem.

10. A hand-supportable Imaging-Based Bar Code Symbol Reader for performing autodiscrimination of 1D/2D bar code symbologies using both narrow-area and wide-area image capture modes of operation.

11. A method of performing autodiscrimination of 1D/2D bar code symbologies in an Imaging-Based Bar Code Symbol Reader having both narrow-area and wide-area image capture modes of operation.

12. A hand-supportable image-based bar code symbol reader employing helically-sweeping feature-extraction analysis on captured 2D images of objects, referenced from the center thereof.

13. A hand-supportable image-based bar code symbol reader employing simple decode image processing operations applied in an outwardly-directed manner on captured narrow-area images of objects bearing 1D bar code symbols.

14. A hand-supportable image-based bar code symbol reader employing an integrated LED-based illumination subsystem with far-field and near-field illumination arrays responsive to control signals generated by an IR-based Object Presence and Range Detection Subsystem during a first mode of system operation and a system control subsystem during a second mode of system operation.

15. A hand-supportable imaging-based bar code symbol reading system employing an integrated LED-based illumination subsystem driven by an Automatic Light Exposure Measurement and Illumination Control Subsystem responsive to control activation signals generated by a CMOS

image sensing array and an IR-based Object Presence and Range Detection Subsystem during object illumination and image capturing operations.

16. A hand-supportable Imaging-Based Bar Code Symbol Reader employing a CMOS image sensing array which activates LED illumination driver circuitry to expose a target object to narrowly tuned LED-based illumination when all of rows of pixels in said CMOS image sensing array are in a state of integration, thereby capturing high quality images independent of the relative motion between said bar code reader and the object.

17. A hand-supportable imaging-based bar code reading system, wherein the exposure time of narrow-band illumination onto its CMOS image sensing array is managed by controlling the illumination time of its LED-based illumination arrays using control signals generated by an Automatic Light Exposure Measurement and Illumination Control Subsystem and a CMOS image sensing array while controlling narrow-band illumination thereto by way of a band-pass optical filter subsystem.

18. A hand-supportable imaging-based bar code reading system employing a mechanism of controlling the image brightness and contrast by controlling the time the illumination subsystem illuminates the target object, thus, avoiding the need for a complex shuttering mechanism for CMOS-based image sensing arrays employed therein.

19. A hand-supportable Imaging-Based Bar Code Symbol Reader employing a multi-mode image-processing bar code symbol reading subsystem that automatically switches its modes of reading during a single bar code symbol reading cycle, and a plurality of different bar code symbology decoding algorithms are applied within each mode of reading.

20. A hand-supportable Imaging-Based Bar Code Symbol Reader, wherein the multi-mode image-processing symbol reading subsystem has a multi-read (e.g. Omniscan/ROI-Specific) mode of operation, for adaptively processing and decoding a captured high-resolution image in a high-speed manner, applying adaptive learning techniques.

21. A hand-supportable Imaging-Based Bar Code Symbol Reader having a multi-mode image-processing symbol reading subsystem with a multi-read (e.g. Omniscan/ROI-Specific) mode of operation, wherein if during the Omniscan Mode of operation, code fragments associated with a PDF417 bar code symbol are detected within a ROI in a captured (narrow or wide) area image, but decode processing thereof is unsuccessful, then the multi-mode image-processing symbol reading subsystem will automatically (i) enter its ROI-Specific Mode of operation described above, and then (ii) immediately commence processing of the captured image at the ROI specified by ROI coordinates acquired by feature vector analysis during the Omniscan Mode of operation.

22. A hand-supportable Imaging-Based Bar Code Symbol Reader having a multi-mode image-processing symbol reading subsystem with a multi-read (e.g. Omniscan/ROI-Specific) mode of operation, which offers an OmniScan Mode of operation to initially and rapidly read 1D bar code symbologies, and various kinds of 2D bar code symbologies whenever present in the captured image, and whenever a PDF417 symbology is detected (through its code fragments), the Multi-Mode Bar Code Symbol Reading Subsystem of the present invention can automatically switch (on-the-fly) to its ROI-specific Mode of operation to immediately process high-resolution image data at a specific ROI (at which there is a high likelihood of a bar code symbol present).

23. A hand-supportable Imaging-Based Bar Code Symbol Reader having a multi-mode image-processing symbol reading subsystem with a multi-read (e.g. NoFinder/ROI-Specific) modeof operation, for adaptively processing a captured high-resolution image in a high-speed manner, applying adaptive learning techniques.

24. A hand-supportable Imaging-Based Bar Code Symbol Reader having a multi-mode image-processing symbol reading subsystem with a multi-read (e.g. NoFinder/ROI-Specific) mode of operation, wherein if during the NoFinder Mode of operation, code fragments associated with a PDF417 bar code symbol are detected within the captured wide-area image, but decode processing thereof is unsuccessful, then the multi-mode image-processing symbol reading subsystem will automatically (i) enter its ROI-specific mode of operation described above, and then (ii) immediately commence processing of the captured wide-area image at a ROI specified

by y coordinates corresponding to the wide-area image processed during the NoFinder Mode of operation.

25. A hand-supportable Imaging-Based Bar Code Symbol Reader having a multi-mode image-processing symbol reading subsystem with a multi-read (e.g. NoFinder/ROI-Specific) mode of operation, wherein the No-Finder Mode can rapidly read 1D bar code symbologies whenever they are presented to the bar code symbol reader, and then whenever a 2D (e.g. PDF417) symbology is encountered, the bar code symbol reader can automatically switch its method of reading to the ROI-specific Mode and use features collected from a narrow (or wide) area image processed during the No-Finder Mode, so as to immediately process a specific ROI in a captured wide-area image frame, at which there is a high likelihood of a bar code symbol present, and to do so in a highly targeted manner.

26. A hand-supportable Imaging-Based Bar Code Symbol Reader having a multi-mode image-processing symbol reading subsystem with a multi-read (e.g. NoFinder/Omniscan/ROI-Specific) mode of operation, for adaptively processing and decoding a captured high-resolution image in a high-speed manner, applying adaptive learning techniques.

27. A hand-supportable Imaging-Based Bar Code Symbol Reader having a multi-mode image-processing symbol reading subsystem with a multi-read (e.g. NoFinder/Omniscan/ROI-Specific) mode of operation, wherein if during the NoFinder Mode of operation, code fragments associated with a PDF417 bar code symbol are detected within the captured narrow-area image, but decode processing thereof is unsuccessful, then the Image Formation and Detection Subsystem (i) automatically captures a wide-area image, while the multi-mode image-processing symbol reading subsystem (ii) automatically enters its Omniscan Mode of operation described above, and then (iii) immediately commences processing of the captured wide-area image at a plurality of parallel spatially-separated (e.g. by 50 pixels) virtual scan lines, beginning at a start pixel and start angle specified by x and/or y coordinates of code fragments detected in the narrow-area image processed during the NoFinder Mode of operation; and, if the Omniscan Mode does not successfully decode a bar code symbol within the ROI, then the multi-mode image-processing symbol reading subsystem (ii) automatically enters its ROI-specific mode of

operation described above, and then (iii) immediately commences processing of the captured wide-area image at a ROI specified by the x,y coordinates corresponding to code fragments detected in the wide-area image processed during the Omniscan Mode of operation.

28. A hand-supportable Imaging-Based Bar Code Symbol Reader having a multi-mode image-processing symbol reading subsystem with a multi-read (e.g. NoFinder/Omniscan/ROI-Specific) mode of operation, wherein the No-Finder Mode can rapidly acquire 1D bar code symbologies whenever they are presented to the bar code symbol reader, and then whenever a 2D symbology is encountered, the bar code symbol reader can automatically switch its method of reading to the OmniScan Mode, collected features on processed image data, and if this reading method is not successful, then the bar code reader can automatically switch its method of reading to the ROI-Specific Mode and use features collected during the Omniscan Mode to immediately process a specific ROI in a captured image frame, at which there is a high likelihood of a bar code symbol present, and to do so in a highly targeted manner.

29. A hand-supportable image-based bar code symbol reader having a Depth of Field (DOF) of about 0 mm to 200 mm (face to 8") for 13.5 mil bar code symbols; wherein the resolution varies as function of object distance; wherein it can decode 5 mil codes somewhere; wherein its optics can resolve 4 mil codes somewhere; where it has a 45° Field of View (FOV).

30. A system for producing a composite DOF plot that completely theoretically characterizes the Depth of Field (DOF) of the image formation optics employed in a Imaging-Based Bar Code Symbol Reader.

31. A hand-supportable imaging-based bar code reading system that employs a novel method of illumination which automatically reduces noise in detected digital images caused by specular reflection during illumination and imaging operations.

32. An Imaging-Based Bar Code Symbol Reader having a multi-mode bar code symbol image processor dynamically reconfigurable in response to real-time image processing operations carried out on captured images.

33. An imaging-based bar code reading system having an integrated led-based illumination subsystem for generating an aiming beam on an a target object and illuminating an aligned 1D bar code symbol thereon in a narrow-area image capture mode of said system, and illuminating randomly-oriented 1D or 2D bar code symbols on said target object in a wide-area image capture mode of said system.

34. An Imaging-Based Bar Code Symbol Reader employing an integrated multi-mode illumination subsystem enabling narrow-area illumination for aiming at a target object and capturing images aligned 1d bar code symbols, and wide-area illumination for capturing images of 1D and 2D bar code symbols.

35. An Imaging-Based Bar Code Symbol Reader employing automatic object presence and range detection to control the generation of near-field and far-field wide-area illumination during bar code symbol imaging operations.

36. An imaging-based auto-discriminating 1D/2D bar code symbol reader employing a multi-mode code symbol decoder dynamically reconfigurable in response to real-time image analysis.

37. An Imaging-Based Bar Code Symbol Reader employing a continuously operating automatic illumination and exposure control subsystem.

38. An Imaging-Based Bar Code Symbol Reader employing a tri-mode led-based illumination subsystem.

39. A method of imaging-based bar code symbol reading employing helically-sweeping feature-extraction analysis on captured 2D images of objects referenced from the center thereof.

40. A method of imaging-based bar code symbol readinging employing simple decode image processing operations applied in an outwardly-directed manner on captured narrow-area images of objects bearing 1d bar code symbols.

41. A method of imaging-based bar code symbol reading employing an integrated LED-based illumination subsystem with far-field and near-field illumination arrays responsive to control signals generated by an IR-based object presence and range detection subsystem during a first mode of system operation and a system controller during a second mode of system operation.

42. A method of imaging-based bar code symbol reading employing an integrated LED-based illumination subsystem driven by an automatic light exposure measurement and control subsystem responsive to control activation signals generated by a CMOS image sensing array and an IR-based object presence and range detection subsystem during object illumination and image capturing operations.

43. A method of imaging-based bar code symbol reading employing a CMOS image sensing array which activates led illumination driver circuitry to expose a target object to narrowly tuned led-based illumination when all of rows of pixels in said CMOS image sensing array are in a state of integration, thereby capturing high quality images independent of the relative motion between said bar code reader and the object.

44. A method of imaging-based bar code symbol reading wherein the exposure time of narrow-band illumination onto its CMOS image sensing array is managed by controlling the illumination time of its LED-based illumination arrays using control signals generated by an automatic light exposure measurement and control subsystem and a CMOS image sensing array while controlling narrow-band illumination thereto by way of a band-pass optical filter subsystem.

45. A method of processing an image along multiple lines of scan data stored in memory and separated by a number of pixel-offset distances proportional to the maximum pixel height of the region of interest (ROI) in the image containing a bar code symbol.

46. A method of imaging-based bar code symbol reading employing a multi-mode image-processing symbol reading subsystem that automatically switches its modes of reading during a

single bar code symbol reading cycle, and within each said mode of reading a plurality of different bar code symbology decoding algorithms are applied.

47. A method of illuminating an object using a hand-supportable Imaging-Based Bar Code Symbol Reader so as to automatically reduce noise in detected digital images caused by specular reflection during illumination and imaging operations.

48. A bar code symbol reader having a multi-mode image-processing based bar code symbol reading subsystem which uses a set of features and constructing a feature-vector to determine a region of interest that may contain a bar code.

49. A bar code symbol reader having a multi-mode image-processing based bar code symbol reading subsystem which uses multiple, adaptive thresholds to determine and mark regions of interest (ROIs).

50. A bar code symbol reader having a multi-mode image-processing based bar code symbol reading subsystem which uses several image processing methods to determine bar code orientation in a hierarchical scheme.

51. A bar code symbol reader having a multi-mode image-processing based bar code symbol reading subsystem which uses several different scan-data filtering techniques to generate bar-space counts.

52. A bar code symbol reader having a multi-mode image-processing based bar code symbol reading subsystem which uses bar and space stitching for correcting perspective and projection transforms and also for decoding damaged labels.

53. A bar code symbol reader having a multi-mode image-processing based bar code symbol reading subsystem which uses incremental processing of an image while image is being progressively acquired.

54. A bar code symbol reader having a multi-mode image-processing based bar code symbol reading subsystem which uses low rise histogram analysis to determine bright spots in captured images.

55. A bar code symbol reader having a multi-mode image-processing based bar code symbol reading subsystem which detects all 1D symbologies and PDF417 omnidirectionally.

56. A bar code symbol reader having a multi-mode image-processing based bar code symbol reading subsystem which decodes UPC/EAN, 1205, C128, C39, C93, CBR omnidirectionally.